# Three-Dimensional Rendering of High-Frequency Ultrasonic Data

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Traditional ultrasonic imaging converts amplitude-time information into a 2-D image by time-gating the data and color-coding the amplitude of the signal in the gate. Unfortunately, this approach throws away the depth information, except for the depth of the time gate. We are capturing all the information in the ultrasonic waveform and processing that information to generate a 3-D image.

Once the image is rendered, it can be manipulated to best display the internal structure of a component. Thus, 3-D rendering of ultrasonic images greatly increases our ability to interpret the data. Our customers gain a better understanding of the results when viewed in 3-D. Also, our ability to characterize components in 3-D will support as-built modeling of the sub- and full assemblies.

The result of this project is a computer workstation capable of processing and rendering complex 3-D ultrasonic data sets. This new tool evaluates engineering materials in 3-D using ultrasonic imaging techniques and provides volumetric information.

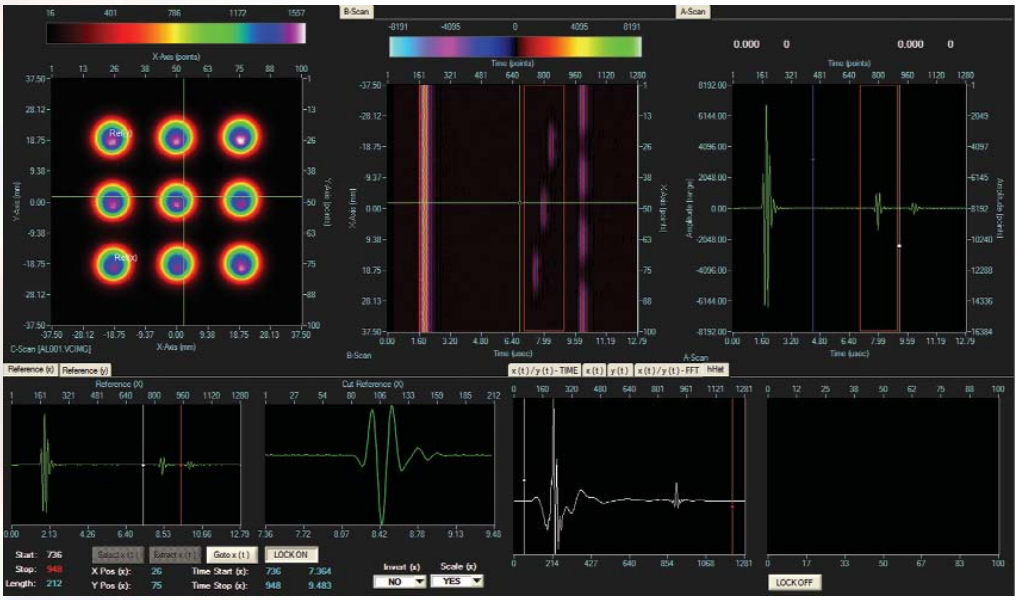


Figure 1. Screen capture of LabWindows CVI-MATLAB user interface. The user is able to view 3-D volume data sets and set-processing variables.

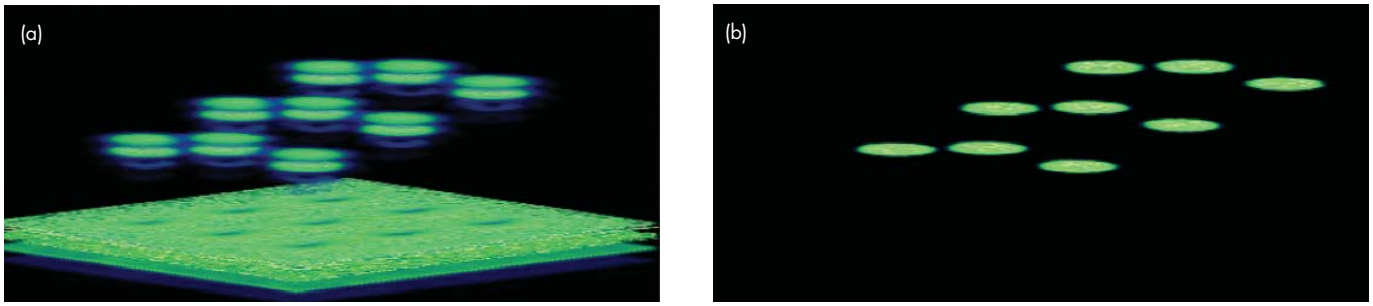


Figure 2. Results of (a) unprocessed (with temporal artifact), and (b) processed (without temoral artifact), 3-D ultrasonic data set acquired on a set of flat bottom holes machined in a test phantom. The holes are 6-mm diameter and located at depths that range from 4.5 to 7.5 mm at 12.7-mm spacing.

## Project Goals

There were three main goals for FY2004: provide a MATLAB signal processing algorithm to remove or minimize the transducer ringing on 1-D time domain signals; provide a computer user interface around the MATLAB code that is a comprehensive utility for interactively processing large 3-D ultrasonic data sets; deploy a computer workstation optimized to process and interactively view and manipulate volumetric 3-D ultrasonic data sets.

## Relevance to LLNL Mission

This ultrasonic volumetric imaging tool will provide quantitative information on engineering materials across many Laboratory programs including NIF, Weapons, and surveillance activities.

## FY2004 Accomplishments and Results

**Algorithms.** We generated a signal processing algorithm and MATLAB software for spatio-temporal resolution enhancement of ultrasonic NDE signals. Given a measured reflection signal and an associated reference signal, the algorithms preprocess the signals (e. g., remove mean, low-pass filter, decimate); produce an optimal least-squares estimate of the impulse response of the material under test; and post-process the signals (e. g., filter, interpolate). The estimated impulse response, when used in place of the raw reflection signal, enhances the spatial resolution of the ultrasonic measurements by removing distortion caused by the limited-bandwidth transducers and the materials under test.

**Computer user interface.** The MATLAB code processes single 1-D time domain signals and was not optimized to process large 3-D ultrasonic data sets containing as many as 250,000 1-D time domain signals. A user interface was needed to provide a utility to read in 3-D volume data sets and to optimize signal-processing variables.

LabWindows CVI (C for Visual Instruments) was used to create the user interface (Fig. 1). The user interface serves three purposes: it is a utility to load and interactively view 3-D ultrasonic data sets; it optimizes MATLAB signal processing input variables; and, using MATLAB engine, it provides a Dynamic Link Library between the user interface code and the MATLAB program environment.

**Computer workstation for 3-D rendering.** Combining the work performed this year on hardware and software, a computer workstation was deployed. The workstation provides a stable platform for engineers and technicians to process and display 3-D ultrasonic data sets in real time, adding insight to the materials inspected and useful volumetric information. Figure 2 shows the results of unprocessed (with temporal artifact) and processed (without temporal artifact) 3-D ultrasonic data sets acquired on a set of flat bottom holes machined in a test phantom.

## Related Reference

Clark, G. A., D. M. Tilly, and W. D. Cook, "Ultrasonic Signal/Image Restoration for Quantitative NDE," *NDT International,* **19,** (3), June 1986.